

## CLAIMS

We claim:

1. A processable rubber composition comprising a cured fluorocarbon elastomer dispersed in a matrix comprising a thermoplastic material,  
wherein the thermoplastic material comprises a non-fluorine containing thermoplastic polymer,  
wherein the cured fluorocarbon elastomer is present at a level of greater than or equal to 35% by weight based on the total weight of cured fluorocarbon elastomer and thermoplastic material.
2. A composition according to claim 1, wherein the cured fluorocarbon elastomer is present at a level of greater than or equal to 40% by weight.
3. A composition according to claim 1, wherein the cured fluorocarbon elastomer comprises repeating units derived from tetrafluoroethylene and propylene.
4. A composition according to claim 1, wherein the thermoplastic polymer comprises an amorphous polymer with a glass transition temperature greater than or equal to 150°C.
5. A composition according to claim 1, wherein the thermoplastic polymer comprises a semi-crystalline material having a melting point greater than or equal to 150°C.
6. A composition according to claim 1, wherein the cured fluorocarbon elastomer comprises repeating units derived from vinylidene fluoride and hexafluoropropylene.

7. A composition according to claim 6, wherein the thermoplastic polymer comprises an amorphous polymer having a glass transition temperature greater than or equal to 150°C.

8. A composition according to claim 6, wherein the thermoplastic polymer comprises a semi-crystalline material having a melting point greater than or greater than or equal to 150°C.

9. A composition according to claim 1, wherein the cured fluorocarbon elastomer comprises repeating units derived from tetrafluoroethylene and perfluoroalkylvinyl ethers,

wherein the perfluoroalkyl vinyl ether contains 1 to 6 carbons in the perfluoroalkyl group

10. A composition according to claim 9, wherein the thermoplastic polymer comprises an amorphous material having a glass transition temperature greater than or equal to 150°C.

11. A composition according to claim 9, wherein the thermoplastic polymer comprises a semi-crystalline material having a melting point greater than or equal to 150°C.

12. A processable rubber composition comprising a cured fluorocarbon elastomer dispersed in a thermoplastic matrix,

wherein the thermoplastic matrix comprises a non-fluorine containing thermoplastic polymer, and

wherein the cured fluorocarbon elastomer is present as a discrete phase or a phase co-continuous with the matrix, and

wherein the dimensions of the elastomer phase are less than 10  $\mu\text{m}$ , as measured by atomic force microscopy on cryogenically microtomed cross-sections of shaped articles formed from the processable rubber composition.

13. A composition according to claim 12, wherein the dimensions of the elastomer phase are less than or equal to 1 $\mu$ m.
14. A composition according to claim 12, wherein the cured fluorocarbon elastomer is present at least in part as particles dispersed in a continuous thermoplastic phase.
15. A composition according to claim 12, wherein the cured fluorocarbon elastomer is present at least in part in a dispersed phase co-continuous with the thermoplastic phase.
16. A composition according to claim 12, wherein the cured fluorocarbon elastomer comprises repeating units derived from tetrafluoroethylene and propylene.
17. A composition according to claim 16, wherein the thermoplastic polymer comprises an amorphous polymer with a glass transition temperature greater than or equal to 150°C.
18. A composition according to claim 16, wherein the thermoplastic polymer comprises a semi-crystalline polymer having a melting point greater than or equal to 150°C.
19. A composition according to claim 12, wherein the cured fluorocarbon elastomer comprises repeating units derived from vinylidene fluoride and hexafluoropropylene.
20. A composition according to claim 19, wherein thermoplastic polymer comprises an amorphous polymer having a glass transition temperature greater than or equal to 150°C.

21. A composition according to claim 19, wherein the thermoplastic polymer comprises a semi-crystalline material having a melting point greater than or equal to 150°C.

22. A composition according to claim 12, wherein the cured fluorocarbon elastomer comprises repeating units derived from tetrafluoroethylene and perfluoroalkylvinyl ethers,

wherein the perfluoroalkyl vinyl ether contains 1 to 6 carbons in the perfluoroalkyl group

23. A composition according to claim 22, wherein the thermoplastic polymer comprises an amorphous material having a glass transition temperature greater than or equal to 150°C.

24. A composition according to claim 22, wherein the thermoplastic polymer comprises a semi-crystalline material having a melting point greater than or equal to 150°C.

25. A processable rubber composition made by a process comprising the step of dynamically vulcanizing a fluorocarbon elastomer in the presence of a non-fluorine-containing thermoplastic material.

26. A composition according to claim 25, made by a process comprising the steps of:

combining an uncured or partially cured fluorocarbon elastomer, a curative agent capable of reacting with the fluorocarbon elastomer to effect cure, and a non-fluorine-containing thermoplastic material;

mixing the combination; and

applying heat to the combination during the mixing step.

27. A composition according to claim 25, made by a process comprising the steps of:

mixing the elastomer and thermoplastic components in the presence of the curative agent, and

heating during mixing to effect cure of the elastomeric components.

28. A composition according to claim 25 made by a process comprising the steps of:

mixing the elastomer material and thermoplastic material for a time and at a shear rate sufficient to form a dispersion of the elastomeric material in a continuous thermoplastic phase;

adding a curative to the dispersion while continuing the mixing; and

heating the dispersion while continuing to mix the curative, elastomeric material, and thermoplastic material.

29. A composition according to claim 25, wherein the curative agent comprises a polyol.

30. A composition according to claim 25, wherein the curative agent comprises a peroxide.

31. A method for making a rubber composition comprising:

forming a mixture by combining a curative, an uncured or partially cured elastomeric material, and a thermoplastic material; and

heating the mixture at a temperature and for a time sufficient to effect vulcanization of the elastomeric material, wherein mechanical energy is applied to mix the mixture during the heating step;

wherein the elastomeric material comprises a fluorocarbon elastomer ; and

wherein the thermoplastic material comprises a non-fluorine-containing polymeric material.

32. A method according to claim 31 comprising:  
mixing the elastomer and thermoplastic components in the presence of a curative agent, and  
heating during mixing to effect cure of the elastomeric component.
33. A method according to claim 31 comprising:  
mixing the elastomeric material and the thermoplastic material for a time and at a shear rate sufficient to form a dispersion of the elastomeric material in a continuous thermoplastic phase;  
adding a curative to the dispersion while continuing the mixing; and  
heating the dispersion while continuing to mix the curative, elastomeric material, and thermoplastic material.
34. A method according to claim 31, wherein the fluorine-containing elastomer comprises repeating units derived from:  
10-90 mole % tetrafluoroethylene;  
10-90 mole % propylene; and  
up to 30 mole % of an additional fluorine containing monomer.
35. A method according to claim 34, wherein the additional monomer comprises vinylidene difluoride.
36. A method according to claim 31, wherein the fluorocarbon elastomer comprises repeating units deriving from vinylidene fluoride and hexafluoropropylene.
37. A method according to claim 36, wherein the fluorocarbon elastomer further comprises repeating units derived from tetrafluoroethylene.

38. A method according to claim 31, wherein the fluorocarbon elastomer is selected from the group consisting of:

VDF/HFP,  
VDF/HFP/TFE,  
VDF/PFVE/TFE,  
TFE/Pr,  
TFE/Pr/VDF,  
TFE/Et/PFVE/VDF,  
TFE/Et/PFVE, and  
TFE/PFVE.

39. A method according to claim 38, wherein the fluorocarbon elastomer also comprises cure site monomers.

40. A method according to claim 31, wherein the curative agent comprises an amine.

41. A method according to claim 31, wherein the curative comprises a polyol.

42. A method according to claim 31, wherein the curative comprises a peroxide.

43. A method according to claim 31, wherein the thermoplastic material comprises a thermoplastic elastomer.

44. A method according to claim 43, wherein the thermoplastic elastomer comprises blocks of polyamide and blocks of polyether.

45. A method according to claim 43, wherein the thermoplastic elastomer comprises blocks of polyether and blocks of polyester.

46. A method according to claim 31, wherein the thermoplastic material comprises a polyamide, a polyester, or a polyolefin.
47. A method according to claim 31, comprising a continuous process.
48. A method according to claim 47, carried out in a twin screw extruder.
49. A method according to claim 31, comprising a batch process.
50. A method according to claim 31, wherein the combination comprises at least about 35 parts by weight vulcanized elastomeric material per 100 parts of the vulcanized elastomeric material and thermoplastic material combined.
51. A method according to claim 31, wherein the combination comprises at least about 45 parts by weight vulcanized elastomeric material per 100 parts of the vulcanized elastomeric material and thermoplastic material combined.
52. A method according to claim 31, wherein the combination comprises at least about 50 parts by weight vulcanized elastomeric material per 100 parts of the vulcanized elastomeric material and thermoplastic material combined.
53. A shaped article comprising a cured fluorocarbon elastomer dispersed in a matrix comprising a thermoplastic material, wherein the thermoplastic material comprises a non-fluorine-containing thermoplastic polymer.
54. A shaped article according to claim 53, wherein the hardness of the article is Shore A 50 or greater, the tensile strength of the article is 4 MPa or greater, the modulus at 100% of the article is 4 Mpa or greater, or the elongation at break of the article is 10% or greater.



55. A shaped article according to claim 53, wherein the cured fluorocarbon elastomer is present at a level of at least 35% by weight based on the total weight of cured fluorocarbon elastomer and thermoplastic polymer.

56. A shaped article according to claim 53 wherein the cured fluorocarbon elastomer is present at a level of at least 50% by weight based on the total weight of cured fluorocarbon elastomer and thermoplastic polymer.

57. An article according to claim 53, wherein the non-fluorine-containing polymer comprises an amorphous polymer having a glass transition temperature greater than or equal to 150°C.

58. An article according to claim 53, wherein the non-fluorine-containing polymer comprises a semi-crystalline polymer having a melting point greater than or equal to 150°C.

59. An article according to claim 53, wherein the fluorocarbon elastomer is selected from the group consisting of:

VDF/HFP,  
VDF/HFP/TFE,  
VDF/PFVE/TFE,  
TFE/Pr,  
TFE/Pr/VDF,  
TFE/Et/PFVE/VDF,  
TFE/Et:PFVE, and  
TFE/PFVE.

60. An article according to claim 53, wherein the thermoplastic polymer comprises a thermoplastic elastomer.

61. An article according to claim 60, wherein the thermoplastic elastomer comprises a polyamide block and a polyester block.

62. An article according to claim 60, wherein the thermoplastic elastomer comprises a polyester block and a polyether block.

63. An article according to claim 53, wherein the thermoplastic polymer comprises a polyamide.

64. An article according to claim 63, wherein the polyamide comprises an aromatic polyamide.

65. An article according to claim 64, wherein the aromatic polyamide comprises repeating units derived from a diamine containing more than 6 carbons and an aromatic diacid.

66. An article according to claim 64, wherein the aromatic polyamide comprises repeating units derived from nonanediamine and an aromatic diacid.

67. A seal according to claim 53.

68. An O-ring according to claim 53.

69. A gasket according to claim 53.

70. A hose according to claim 53.

71. A continuous process for making a processable rubber composition comprising:

combining a fluorocarbon elastomer, curative agent, a thermoplastic material comprising a non-fluorine containing thermoplastic polymer in a twin screw extruder, mixing the combination in the twin screw extruder for a time and at a temperature sufficient to effect cure of the fluorocarbon elastomer, and extruding the cured mixture.

72. A process according to claim 71 comprising:

injecting a combination of the fluorocarbon elastomer and thermoplastic material into the twin screw extruder with a first feeder, and

injecting the curative agent into the screw extruder with a second feeder downstream from the first feeder.

73. A process according to claim 71, wherein the fluorocarbon elastomer and curative agent are formulated together into a pre-compound.

74. A process according to claim 71, wherein the fluorocarbon elastomer comprises repeating units derived from tetrafluoroethylene and propylene.

75. A process according to claim 71, wherein the fluorocarbon elastomer comprises repeating units derived from vinylidene fluoride and hexafluoropropylene.

76. A process according to claim 71, wherein the fluorocarbon elastomer is selected from the group consisting of:

VDF/HFP,  
VDF/HFP/TFE,  
VDF/PFVE/TFE,  
TFE/Pr,  
TFE/Pr/VDF,  
TFE/Et/PFVE/VDF,  
TFE/Et/PFVE, and  
TFE/PFVE.

77. A process according to claim 71, wherein the thermoplastic material comprises a thermoplastic elastomer.

78. A process according to claim 77, wherein the thermoplastic elastomer comprises polyamide blocks and polyester blocks.

79. A process according to claim 77, wherein the thermoplastic elastomer comprises blocks of polyester and blocks of polyether.

80. A process according to claim 71, wherein the thermoplastic material comprises an aromatic polyamide.

81. An article according to claim 80, wherein the aromatic polyamide comprises repeating units derived from a diamine containing more than 6 carbons and an aromatic diacid.

82. An article according to claim 80, wherein the aromatic polyamide comprises repeating units derived from nonanediamine and an aromatic diacid.

83. A method for reducing costs of a manufacturing process for making shaped rubber articles from a processable rubber composition, comprising recycling scrap material generated during the manufacturing process to make new shaped articles comprising the processable rubber composition,

wherein the processable rubber composition is the product of dynamic vulcanization of a fluorocarbon elastomer in the presence of a thermoplastic material, wherein the thermoplastic material comprises a non-fluorine containing thermoplastic polymer.

84. A method according to claim 83, wherein the manufacturing process comprises forming the shaped articles by a thermoplastic processing technique.

85. A method according to claim 83, wherein the thermoplastic processing technique is selected from the group consisting of blow molding, injection molding, compression molding, and extrusion.

86. A processable rubber composition comprising a cured fluorocarbon elastomer dispersed in a thermoplastic matrix,

wherein the thermoplastic matrix comprises an aromatic polyamide, and

wherein the cured fluorocarbon elastomer is present at a level of greater than or equal to 35% by weight based on the total weight of cured fluorocarbon elastomer and aromatic polyamide.

87. A composition according to claim 86, wherein the cured fluorocarbon elastomer is present at a level of greater than or equal to 40% by weight.

88. A composition according to claim 86, wherein the cured fluorocarbon elastomer comprises repeating units derived from tetrafluoroethylene and propylene.

89. A composition according to claim 86, wherein the cured fluorocarbon elastomer comprises repeating units derived from vinylidene fluoride and hexafluoropropylene.

90. A composition according to claim 86, wherein the cured fluorocarbon elastomer comprises repeating units derived from tetrafluoroethylene and perfluoroalkylvinyl ethers,

wherein the perfluoroalkyl vinyl ether contains 1 to 6 carbons in the perfluoroalkyl group.

91. A composition according to claim 86, wherein the aromatic polyamide comprises repeating units derived from an aromatic diacid and a diamine having more than 6 carbon atoms.

92. A composition according to claim 91, wherein the diamine has 7 to 20 carbon atoms.

93. A composition according to claim 91, wherein the diamine has 9 to 12 carbon atoms.

94. A composition according to claim 91, wherein the diamine has 9 carbon atoms.

95. A composition according to claim 91, wherein the diacid is terephthalic acid.